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ABSTRACT

Incentive, practice, instruction, and feedback were manipulated in a series of four 2 x 2 factorial studies, with Air Force Reserve Officer Training Corps cadets and graduate students in education, to determine the individual and combined effects of these variables on learner performance (both speed and accuracy) of an aircraft comprehension task. For each of the experiments, the report provides details on: methods, subjects, materials, procedures, criterion measures, design and data analyses, results, and discussion of results. Although cadets who either practiced the task or were offered an incentive performed significantly faster on the post-test than learners who did not receive these treatments, the experiments generally indicated that instruction, when it is well-designed, appears to be a variable of such impact that it leaves little room for improvement in learner performance that might be attributable to such refinement as practice, incentive, and feedback. Sample instructional, practice, and post-test materials and tables of results are included. (Author/PR)

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SYSTEMATIC VARIATIONS OF INSTRUCTIONAL VARIABLES ON LEARNER PERFORMANCE:

AIRCRAFT INSTRUMENT COMPREHENSION TASK

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This technical report has been reviewed and is approved.

WILLIAM V. HAGIN, Technical Director
Flying Training Division

Approved for publication.

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Incentive, practice, instruction, and feedback were manipulated in a series of four 2 x 2 factorial studies, with AFROTC cadets and graduate students in education, to determine the individual and combined effects of these variables on learner performance of an aircraft instrument comprehension task. AFROTC cadets, who either practiced the task or were offered a performance-contingent incentive, performed significantly faster on the posttest than learners who did not receive these treatments. No significant feedback effects were observed in any of the studies. These results are discussed in terms of instruction, as the variable of singular importance in designing materials and procedures to facilitate desired learning outcomes.

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PREFACE

This study was conducted under Project 1123, USAF Flying Training Development, Task 1123-02, Instructional Innovations in USAF Flying Training.

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SYSTEMATIC VARIATIONS OF INSTRUCTIONAL VARIABLES ON LEARNER PERFORMANCE: AIRCRAFT INSTRUMENT COMPREHENSION TASK

Although many instructional variables have been shown to facilitate learning, few of these variables appear to make a consistent contribution to learner performance under a variety of instructional conditions. And, the lack of comparability across studies that have attempted to examine the effects of these variables makes it difficult to determine the contribution of each of these variables to the effectiveness of instructional materials and procedures. The present research bridges this gap in conventional instructional research by systematically manipulating potentially powerful variables under a common set of experimental procedures.

The primary focus of the present research is to determine "what works in effective instruction." The fundamental emphasis of the present approach is upon using effective instruction as the research vehicle for determining the variables of which instructional effectiveness is a function. The overriding emphasis of previous instructional research efforts has been upon the variables per se, with little regard for carefully defining the experimental task and then providing methods and materials that ensure learner proficiency on the task. In contrast, the present research strategy employs a systematically developed instructional program of empirically established effectiveness. Two tryouts of the aircraft instrument comprehension program were conducted to verify its effectiveness in consistently producing criterion-level proficiency in target population learners. The program is designed to train learners to identify which one

of four pictures of aircraft in flight most nearly corresponds to the position indicated on a panel of attitude and heading instruments. For each of the three positional concepts taught in the program (roll, pitch, and heading), instruction consists of providing the learner with the rule for identifying examples of the concept, along with approximately five examples of the concept. Practice exercises require the learner to identify the picture of an aircraft that most closely approximates the position of the aircraft represented by the attitude and heading instruments. Learners responding to each practice exercise receive immediate feedback for their responses in the form of knowledge of correct response.

Using the aircraft instrument comprehension task, the individual and combined effects of practice, incentive, instruction, and feedback on learner posttest performance were investigated in a series of four factorial studies. Two distinct learner populations, AFROTC cadets and graduate education students, were studied in isolating the effects of these variables. Learner posttest performance was reflected by two measures: accuracy, or the number of correct responses emitted, and time required to respond to all items on the posttest.

It was expected that the output of this line of research would result in an increased knowledge of the individual and combined effects of variables that are under the control of the instructional developer. This knowledge should facilitate future attempts at designing instructional products that are both effective and efficient in producing desired learning outcomes.

EFFECTS OF PRACTICE AND INCENTIVE

EXPERIMENT I

Experiment I was conducted to determine the individual and combined effects of practice and incentive in facilitating learner posttest performance on the aircraft instrument comprehension task.

Method

Subjects--Forty-eight male Air Force Reserve Officer Cadets enrolled in their third year of studies at Arizona State University served as the subjects in this study. All cadets in the study had previously taken the Air Force Officer Qualifying Test.

Materials--Variations of the self-instructional materials were studied. The program was designed to achive the following instructional objective:

> Given four illustrations of aircraft in roll, pitch, and heading, the student will identify the illustration that most nearly represents the position indicated on a compass and an artificial horizon. An acceptable performance will consist of identifying at least 90% of the correct response alternatives on a 36-item instrument comprehension test.

Instructions in the program consisted of one instructional cue and three examples for each of the three concepts presented: pitch, bank, and heading. Eight examples were also presented in which these concepts were combined. Practice consisted of one to four practice items for each concept, followed by additional 10 practice items at the end of the program. All practice items required Ss to identify which of two or more drawings of an aircraft in flight most nearly represented the position shown on an attitude indicator and a heading indicator. Sample instructional materials are contained in Appendix A; sample practice items may be found in Appendix B.

Upon completion of each practice item, feedback was available to S by moving a paper slide.

Procedure--Ss were assigned to treatment groups by a procedure that made it unlikely that Ss in the no incentive conditions were informed of the incentive being used in other groups. Since Ss attended classes in four different sections that met on two consecutive days, all Ss in the first two sections were assigned to the no incentive conditions, and all Ss in the subsequent two sections were assigned to the incentive conditions. Within each class section, half of the Ss were randomly assigned to the practice conditions, and the remaining half were assigned randomly to the no practice conditions.

All Ss were administered a pretest one week prior to initiating the experiment. Ss were allowed a maximum of three minutes to complete the nine pretest items. During each experimental session, S read the instructional materials and responded to items on a posttest. A proctor displayed the time on 8½" x 11" cards at the front of the room at 0.25 minute intervals throughout the experimental session. Ss were instructed to complete the instructional booklet assigned to them, and to record their completion times for the instructional booklets. Proctors collected the booklets as the Ss finished them. The posttest was administered after all Ss had completed the instructional booklets. Ss were again asked to record their completion times, and the test booklets were collected as each S finished.

Ss in the incentive conditions received written instructions located at the beginning of their instructional booklets indicating that they could earn up to nine quiz points on their course grade by responding accurately to the items on the posttest. In addition, the instructions indicated that

the four cadets who responded to the posttest items with the greatest accuracy, and in the least amount of time, would have an opportunity to "fly" a formation trainer at Williams Air Force Base, Arizona. Instructions to Ss in the no incentive conditions simply stated that their grades in the course would not be affected by their participation in the "tryout" and that the developers of the self-instructional program would "appreciate their best efforts."

Ss in the no practice conditions received instructional booklets in which all practice items were deleted from the program. Booklets for each S in this condition contained only the instructional cues and examples for each concept taught in the program. The booklets for Ss in the practice conditions contained approximately twice as many pages as the booklets that did not include practice items.

Criterion Measures--The posttest contained directions, a sample test item, and 36 multiple-choice items. Appendix C contains a sample test item. All test items required S to identify which one of four drawings of an aircraft in flight most nearly represented the position shown on an attitude indicator and a heading indicator. A pretest consisting of nine items selected to be representative of items on the posttest was also employed.

The test item pool consisted of 72 different positions of an aircraft in flight. Three dimensions of the aircraft's position (pitch, roll, and heading) were systematically varied to create the item pool. Three levels of pitch were used: level, climb, and dive. Three levels of roll were used: no bank, 30° right bank, and 30° left bank. Eight levels of heading were used: four primary compass headings (N, S, E, W) and four intermediate compass headings (NE, SE, NW, SW). As described in the validation

report (Higgins, Kearns, and Tenpas, 1974), the posttest items were systematically selected to represent equally the variations in heading, pitch and roll.

In addition to recording the number of correct responses emitted by each S on the posttest, the amount of time that S required to complete the items on the posttest was recorded to the nearest 0.25 minute. This was accomplished by noting the simultaneous starting time of all Ss and requiring each S to record on his answer sheet the time shown on a card held by a proctor at the front of the room. Anecdotal observations by two other proctors in the room indicated that S's self-recordings were veridical.

Data Analyses--The pretest-treatment-posttest experimental arrangement constituted a 2 x 2 factorial design with 12 Ss in each of the four cells. Analyses of variance were made to determine the individual and combined effects of practice and incentive on posttest scores and posttest times. Each analysis was evaluated at the .05 level of confidence.

Results

An analysis of scores on the 9-item pretest revealed that the mean scores across the treatment groups varied less than 0.25 points from the overall mean pretest score of 6.25 (Table 1). As can be seen from Table 2, these differences were not statistically significant. These results add confidence to our assumption of equivalence across treatment groups with respect to S's entry skills on the experimental task.

The mean posttest scores of the treatment groups (Table 3) were all within one-point of the overall mean score of 33.31. F-ratios for incentive, practice, and the practice X incentive interaction were not

TABLE 1

Mean Pretest Scores (number correct of 9 possible points) by Treatment

Incentive	Practice		Totals
	Practice	No Practice	
Incentive	6.42	6.08	6.25
No Incentive	6.25	6.25	6.25
Totals	6.33	6.17	6.25

TABLE 2

Analysis of Variance: Pretest Scores

Source of Variation	SS	df	MS	F-Ratio	
Incentive	0.00	1	0.00	0.00	NS*
Practice	.33	1	.33	.07	NS
Incentive X Practice	.33	1	.33	.07	NS
Within	200.33	44	4.55		

*NS = Not Significant

TABLE 3

Posttest Mean Scores (number correct of 36 possible points) by Treatment

Incentive	Practice		Totals
	Practice	No Practice	
Incentive	33.33	32.42	32.88
No Incentive	33.50	34.00	33.75
Totals	33.42	33.21	33.31

TABLE 4

Analysis of Variance: Posttest Scores

Source of Variation	SS	df	MS	F-Ratio	
Incentive	9.19	1	9.19	1.12	NS
Practice	.52	1	.52	.06	NS
Incentive X Practice	6.02	1	6.02	.73	NS
Within	360.58	44	8.20		

statistically significant (Table 4). A performance gain was observed between the pretest scores and the posttest scores. On the pretest, Ss answered a mean of 69.4% of the items correctly; Ss answered a mean of 92.5% of the items correctly on the posttest.

Ss spent differential amounts of time answering items on the posttest. Mean posttest times by treatment are reported in Table 5. Posttest time differences were analyzed using an analysis of variance, as shown in Table 6. Statistically significant differences were found for both practice ($F = 22.3$, $df = 1/44$, $p < .001$) and for incentive ($F = 15.4$, $df = 1/44$, $p < .001$). The practice X incentive interaction was not significant.

A further analysis was made to determine whether the experimental variations facilitated attainment of the task objective. The objective indicated that Ss should be able to respond accurately to at least 90% (or, 32 out of 36) of the items on the posttest. No appreciable variation in the number of Ss who exceeded this performance level was observed that might be attributed to either practice or incentive. However, an increase in the number of Ss exceeding the 90% performance level on the pretest, while 81% exceeded this level on the posttest. Of the 12 Ss in the treatment group that received neither practice nor incentive, 4 (33%) of the Ss exceeded the prespecified 90% performance level on the pretest, but 10 (83%) of the Ss attained the objective on the posttest.

Discussion

Experiment I was conducted to determine the individual and combined effects of practice and incentive in facilitating learner posttest performance on the aircraft instrument comprehension task. The results indicated

TABLE 5

Mean Posttest Times (minutes) Treatment

Incentive	Practice	No Practice	Totals
Incentive	5.98	8.13	7.05
No Incentive	7.79	9.60	8.70
Totals	6.88	8.86	7.88

TABLE 6

Analysis of Variance: Posttest Times

Source of Variation	SS	df	MS	F-Ratio
Incentive	32.50	1	32.50	15.42*
Practice	47.00	1	47.00	22.31*
Incentive X Practice	0.09	1	0.09	0.04
Within	93.02	44	2.11	

*$p < .001$

that neither variable significantly affected the accuracy of posttest performance. Ss in the treatment group that simply read the instructional materials had a mean score of 34 on the 36-item posttest. Such a high mean posttest score created a ceiling effect that left little room for improvement that could be attributed to either practice or incentive. That is, the increase that was observed between pretest and posttest scores appeared to be attributable to the instructional materials per se; the experimental variables had little effect in controlling the accuracy of posttest performance. Also, a pretest-posttest comparison of the number of subjects attaining the objective showed an increase that appeared to be attributable to the instructional materials.

An analysis of the time required for learners to complete the posttest showed a different picture. The amount of time required for learners to complete the posttest was significantly reduced both by the incentive that was offered, and by the practice provided in the instructional program. In addition to being a criterion measure that appears less susceptible to the ceiling effects imposed by posttest scores, posttest time may have considerable external validity with respect to pilot training. Indeed, the speed with which an individual can accurately read and respond to instruments may prove an important predictor of later pilot effectiveness.

EFFECTS OF INSTRUCTION AND FEEDBACK CONTINGENCY

EXPERIMENT II

Previous studies indicate that feedback in the form of knowledge of the correct response (KCR) does not enhance learner performance on the aircraft instrument comprehension task beyond that attributable to instruction alone. Also, the results of Experiment I suggested that instruction per se is the major factor controlling learner posttest accuracy scores. However, these studies utilized a paper slide device to present KCR, and many of the learners were observed to ignore the slide and proceed through the program without receiving feedback. It is indeed possible that KCR failed to significantly enhance learner performance simply because the learners found it "inconvenient" to move the paper slide in order to obtain this feedback.

The purpose of Experiment II was to determine the individual and combined effects of instruction and the contingencies for obtaining feedback on learner posttest performance. Also, in order to reduce the ceiling effect that was observed with posttest scores in Experiment I, an effort was made to procure learners that were expected to be less skilled at the aircraft instrument comprehension task than AFROTC cadets. Two levels of instruction were examined: instruction and the absence of instruction. The two types of feedback contingencies employed in the study were KCR received immediately contingent on responding to practice exercises, and KCR received contingent on moving a paper slide device to reveal the correct response after responding.

Method

Subjects--Thirty-six Arizona State University graduate education students enrolled during the spring semester of 1974 served as the subjects in this study.

Materials--The aircraft instrument comprehension program described in Experiment I was used. Half of the Ss marked their program responses on chemically treated answer sheets (A. B. Dick Company) designed to provide KCR. A latent image in the form of an "X" appeared immediately when S touched the appropriate space with the special pen provided. Program response sheets and marking pens appeared identical for all Ss, regardless of the experimental condition. Ss who did not receive the chemically treated answer sheets were required to manipulate a paper slide device in order to obtain KCR.

Procedure--Ss were informed that their participation in the "tryout" was appreciated and that the developers of the self-instructional program would "appreciate their best efforts." Other than an attempt to appeal to the education majors' interest in the quality of instructional products, no extrinsic incentives were offered contingent on learner performance. Also, Ss were assumed to be naive with respect to the aircraft instrument comprehension task; consequently, no pretest was administered.

Upon entering their classroom on the day of the study, Ss were randomly assigned to one of four treatment groups. Each treatment group received a different set of materials. Ss in the instruction groups received the complete set of instructional booklets described in Experiment I. Ss in the no instruction groups received an instructional booklet with all

instructional cues and examples removed. All Ss began work on the program at the same time and were instructed to record the time on their answer sheets and raise their hands when they were finished. A proctor displayed the time at 0.25 minute intervals throughout the program and posttest. Following completion of the program, each S's instructional booklet was removed and replaced with a test booklet, answer sheet, and marking pen. The time each S began the posttest was recorded on his/her answer sheet by a proctor. Directions on the first page of the posttest booklet indicated that Ss were to work as quickly as possible without sacrificing accuracy. Ss recorded the time they finished the test on their answer sheets; they were free to leave as soon as proctors collected their test materials.

Criterion Measures--Posttest time and accuracy were recorded for each S, as described in Experiment 1.

Data Analysis--The posttest-only control group arrangement resulted in a 2 x 2 factorial design, with 9 Ss in each of the 4 cells. Analyses of variance were used to determine the individual and combined effects of instruction and feedback contingency on posttest scores and posttest times. Each of the analyses was evaluated at the .05 level of confidence.

Results

Tables 7 and 8 show a significant main effect for instruction on the posttest scores ($F = 8.91$, $df = 1/32$, $p < .01$). Ss in the groups receiving instruction, regardless of the feedback contingency employed, scored an average of 5.66 points higher on the 36-item posttest than S in the no instruction conditions. Differences in posttest time were not statistically significant, as shown in Tables 9 and 10. An inspection of individual S

TABLE 7

Posttest Mean Scores (number correct of 36 possible points)

Instruction	Feedback Contingency: Response Contingent	Feedback Contingency: Slide-use Contingent	Totals
Instruction	25.41	21.71	23.72
No Instruction	16.44	15.64	16.05
Totals	21.05	18.72	13.24

N = 9 per cell

TABLE 8

Analysis of Variance: Posttest Scores

Source of Variation	MS	DF	F-Ratio	
Instruction	592.00	1	8.91*	
Feedback Contingency	49.00	1	.83	NS
Instruction X Feedback	21.74	1	.37	NS
Within	59.37	32		
Total	71.43	35		

*$p < .01$

TABLE 9

Mean Posttest Times (minutes) by Treatment

	Feedback Contingency		
Instruction	Response Contingent	Slide-Use Contingent	Totals
Instruction	12.11	12.17	12.14
No Instruction	13.31	11.08	12.19
Totals	12.71	11.63	12.17

TABLE 10

Analysis of Variance: Posttest Times

Source of Variation	MS.	DF	F-Ratio	
Instruction	.03	1	.00	NS
Feedback Contingency	10.56	1	.33	NS
Instruction X Feedback	11.67	1	.36	NS
Within	32.18	32		
Total	30.06	35		

performance scores revealed that only 7 of the 36 Ss exceeded the minimum performance level of 90% correct on the posttest. All 7 of these Ss were in treatment groups that received instruction.

Discussion

Experiment II was conducted to investigate the individual and combined effects on instruction and feedback contingency on the speed and accuracy of learner posttest performance. The results indicated a significant effect for instruction; neither the main effect for feedback contingency nor the instruction X feedback interaction were statistically significant. However, the generality of these results were quite limited by the fact that less than 40% of the learners receiving instruction exceeded the minimal performance score of 32 on the 36-item posttest. These results suggest that the aircraft instrument comprehension program may not be effective in attaining the task objective with relatively naive learners. However, an incentive was not provided for the learners to "try their best" on the materials; this may have been responsible for the low overall performance that was observed. Additional data with similar learners is obviously indicated in order to clarify these ambiguous results.

EFFECTS OF INSTRUCTION AND PRACTICE

EXPERIMENT III

The results of Experiment I indicated that practice and incentive do not significantly enhance the accuracy of learner posttest responses on the aircraft instrument comprehension task. Based on these results, it was suggested that instruction may be a major factor in maintaining high posttest performance levels. However, the learners in that experiment were already reasonably proficient at performing the task being taught, as indicated by their high pretest scores. Perhaps practice would significantly enhance posttest performances in cases where learners were not familiar with the task. The purpose of Experiment III, therefore, was to determine the individual and combined effects of instruction and practice on the posttest performances of relatively "naive" learners.

Method

Subjects--Fifty-two undergraduate students enrolled in an educational psychology course at Arizona State University during the spring semester of 1974 served.

Materials--The materials in this study remained identical to those described in Experiment II.

Procedures--Upon entering their classroom on the day of the study, Ss were randomly assigned to one of four treatment groups. Each treatment group received a different set of materials. The instruction and practice group received an instructional booklet with all instructional cues, examples, and practice items intact. The instruction only group received

an instructional booklet with all the practice items deleted. The no practice-no instruction group received only a posttest booklet; Ss did not receive instructional cues, examples, or practice items.

All Ss received oral instructions indicating that they were participating in an experiment, and that they would receive extra credit toward their grade in the course in return for their participation. Also, the first page of each instructional booklet indicated that Ss could earn up to nine points of extra credit if they responded quickly and accurately on a subsequent posttest. The instructions also indicated that various types of materials had been distributed and that each S would be competing for extra credit only against other Ss that received the same materials.

The last page of each instructional booklet directed S to record the time he had finished his booklet (as displayed on the time card held by a proctor at the front of the room), and to raise his hand so that a proctor could collect his materials. The proctor checked the completion time S had listed, collected the materials, and instructed Ss who had taken the posttest that they could leave. Ss who had completed a version of the instructional program were given a copy of the posttest by the proctor, who recorded S's starting time. When Ss finished the posttest, he recorded his completion time, had his material collected by a proctor, and was dismissed.

Criterion Measures--The criterion measures remained identical to those described in Experiment I.

Design and Data Analyses--The posttest-only control group arrangement constituted a 2 x 2 factorial design. Analyses of variance were made to determine the individual and combined effects of instruction and practice

on posttest scores and posttest time. The results of each analysis were evaluated at the .05 level of confidence.

Results

Table 11 shows the mean posttest scores by treatment. The mean score for groups receiving instruction was almost 14 points higher than the mean score for groups not receiving instruction. Differences in mean scores between groups receiving practice and groups not receiving practice was less than one point. A two-way analysis of variance (Table 12) revealed a statistically significant difference attributable to instruction ($F = 82.62$, $df = 1/48$, $p < .001$). F-ratios for practice and the practice X incentive interaction were not statistically significant. A further inspection of the posttest scores revealed that 11 (42%) of the Ss in the group that received instruction exceeded the 90% minimum performance level established for the task.

Mean posttest times by treatment are shown in Table 13. Table 14 indicates that the F-ratios for instruction, practice, and their interaction were not statistically significant with respect to posttest time.

Discussion

Learners that received instruction scored significantly higher on the posttest than learners who did not receive instruction. Neither the presence of instruction nor the combination of instruction and practice significantly enhanced learner performance beyond the effects attributable to instruction alone.

TABLE 11

Posttest Mean Scores (number correct of 36 possible points) by Treatment

Instruction	Practice		Totals
	Practice	No Practice	
Instruction	28.07	31.53	29.80
No Instruction	16.61	15.07	15.84
Totals	22.34	23.30	22.82

TABLE 12

Analysis of Variance: Posttest Scores

Source of Variation	SS	df	MS	F-Ratio	
Instruction	2534.02	1	2534.02	82.62*	
Practice	12.02	1	12.02	.39	NS
Instruction X Practice	81.25	1	81.25	2.65	NS
Within	1472.16	48	30.67		

*$p < .001$

TABLE 13

Mean Posttest Time (minutes) by Treatment

Instruction	Practice	No Practice	Totals
Instruction	13.65	15.51	14.58
No Instruction	13.30	15.01	14.15
Totals	13.47	15.26	14.36

TABLE 14

Analysis of Variance: Posttest Times

Source of Variation	SS	df	MS	F-Ratio	
Instruction	2.32	1	2.32	0.13	NS
Practice	41.58	1	41.58	2.50	NS
Instruction X Practice	0.08	1	0.08	0.01	NS
Within	797.44	48	16.61		

These results hardly seem surprising. Instruction should enhance the performance of learners beyond that of learners who do not receive such instruction. What is significant about these findings, however, is the pattern of results that is beginning to emerge from the three studies that have been considered thus far. Instruction, when it is well-designed, appears to be a variable of such impact that it leaves little room for improvement in learner performance that might be attributable to other refinements such as practice, incentive, and feedback.

Feedback is a particularly interesting case in point. Recent years have produced a plethora of research in the area of feedback effects on learner performance (cf. Anderson, 1967; Annett, 1969; Briggs and Hamilton, 1964; Gagne and Rowher, 1969). And, the results have been far from consistent in this area: feedback sometimes enhances performance over learners that do not receive feedback during instruction; frequently it does not. Relatively few of these studies, however, have employed systematically developed instructional materials (Higgins, 1972). It may be that the effectiveness of feedback in enhancing learner performance varies directly with the degree to which materials are systematically designed to ensure learner attainment of prespecified instructional objectives.

EFFECTS OF FEEDBACK AND INSTRUCTION

EXPERIMENT IV

Experiment IV was conducted to determine the individual and combined effects of instruction and feedback in the aircraft instrument comprehension program. Two levels of instruction were investigated (presence and absence), along with two levels of feedback (also, presence and absence). If instruction is a variable of such import that it negates the effectiveness of feedback, as indicated in the above discussion, then feedback should be observed to enhance learner performance only in the absence of instruction.

Method

Subjects--Sixty-three junior and senior college students, enrolled in the Air Force Research Officer Training program at the University of Arizona, served as the subjects in this study. All Ss had previously taken the Air Force Officer Qualifying Test.

Materials--All materials remained identical to those reported in the previous experiments.

Procedures--Ss were divided between two experimental sessions. During each session Ss were randomly assigned to one of four treatment groups: instruction and feedback, instruction and no feedback, feedback and no instruction, or no feedback and no instruction. Performance incentives contingent upon both speed and accuracy of S's posttest responding were identical to those described in Experiment I. Ss were informed of the incentives through oral directions given at the beginning of each

experimental session. The incentives were identical for all treatment groups.

At the beginning of the session, Ss were given general oral directions about the study, a 9-item pretest, and an IBM response sheet. Following completion of the pretest, all Ss were given the instructional program booklet and either a chemically treated or nonchemically treated response sheet. Each S received a special marking pen regardless of the nature of his response sheet. The feedback groups were instructed to mark the chemically treated response sheet as many times as necessary to reveal the KCR for each practice item in the program. A standard time lapse of 0.25 minute intervals was displayed for all Ss. As Ss completed the instructional program, proctors monitored each S's recording of his completion time, picked up program materials, and distributed the criterion test.

Criterion Measures--The criterion measures were identical to those described in Experiment I.

Design and Data Analyses--The pretest-posttest experimental arrangement constituted a 2 x 2 factorial design. Analyses of variance were made to determine the individual and combined effects of instruction and feedback on posttest performance and posttest time. The results of each analysis were tested at the .05 level of confidence. Group means on the pretest were evaluated using an analysis of variance to determine the similarity of treatment groups. Ss who received a score of seven or more on the pretest were considered to be proficient on the task prior to the experiment and were eliminated from all data analyses reported.

Results

The mean score for each group on the 9-item pretest is shown in Table 15. No statisitically significant differences were observed in pretest scores across the treatment groups (Table 16).

The mean score for each group on the 36-item criterion test is shown in Table 17. The mean score for the instruction group was approximately 4 points higher than the no instruction group; the feedback group scored about 2 points higher than the no feedback group. An analysis of these scores revealed a significant difference for instruction ($F = 4.73$, $df = 1/37$, $p < .05$); differences for either feedback or the instruction X feedback interaction were not significant (Table 18).

Mean times required for each group to complete the posttest are reported in Table 19. The mean time for the instruction group, 7.14 min, was less than the mean time of 8.21 min for the no instruction group. The mean time of 7.93 min for the feedback group exceeded the mean time of 7.30 min for the no feedback group. A two-way analysis of variance (Table 20) again revealed a significant difference for instruction ($F = 4.45$, $df = 1/37$, $p < .05$), but no significant differences for either feedback or the instruction X feedback interaction were observed.

Discussion

The results of Experiment IV indicate that instruction ehances both the accuracy and the rate at which the learners responded to items on the posttest. However, the anticipated interaction between feedback and instruction was not obtained. Feedback did not enhance posttest performance

TABLE 15

Mean Pretest Scores (number correct of 9 possible points) by Treatment

Instruction	Feedback		Totals
	Feedback	No Feedback	
Instruction	5.88	5.44	5.66
No Instruction	5.53	5.50	5.52
Totals	5.70	5.47	5.59

N = 16 per cell

TABLE 16

Analysis of Variance: Pretest Scores

Source of Variation	SS	df	MS	F-Ratio	
Instruction	0.32	1	0.32	0.13	NS
Feedback	0.89	1	0.89	0.37	NS
Instruction X Feedback	0.65	1	0.65	0.27	NS
Within	143.42	60	2.39		

TABLE 17

Mean Posttest Scores (number correct out of 36 possible points) by Treatment

Instruction	Feedback		Totals
	Feedback	No Feedback	
Instruction	32.32	31.73	32.06
No Instruction	31.67	25.24	27.84
Totals	31.99	28.48	29.95

TABLE 18

Analysis of Variance: Posttest Scores*

Source of Variation	SS	df	MS	F-Ratio	
Instruction	18.05	1	18.05	4.73*	
Feedback	8.69	1	8.69	2.28	NS
Instruction X Feedback	5.07	1	5.07	1.33	NS
Within	140.99	37	3.81		

*$p < .05$

TABLE 19

Mean Posttest Times (Minutes) by Treatment

Instruction	Feedback		Totals
	Feedback	No Feedback	
Instruction	7.18	7.11	7.14
No Instruction	8.68	7.50	8.21
Totals	7.93	7.30	7.61

TABLE 20

Analysis of Variance: Posttest Times

Source of Variation	SS	df	MS	F-Ratio	
Instruction	.89	1	.89	4.45*	NS
Feedback	.39	1	.39	1.95	NS
Instruction X Feedback	.30	1	.30	1.50	NS
Within	7.75	37	.20		

*$p < .05$

even when instruction was withheld from the learners. These results serve to further reinforce the idea that instruction is the predominant variable controlling learner performance in the aircraft instrument comprehension task.

GENERAL DISCUSSION

The results of Experiments I-IV are summarized in Table 21. The most salient conclusion that emerges from these data concerns the overpowering effect that instruction alone has on learner performance of the aircraft instrument comprehension task. In Experiment I, the treatment group that simply read the instructional materials had a mean score of 34 on the 36-item posttest. Such a high mean score left little room for improvement that could be attributed to either the practice or the incentive variable.

In Experiment II and III, no significant differences were found for either feedback or practice; instruction alone was responsible for the observed differences in mean treatment group scores. And, this pattern continued in Experiment IV, where feedback failed to contribute significantly to posttest performance--even in the treatment group for which instruction was withheld.

The present research points to instruction as the variable of singular importance in designing effective materials and procedures to facilitate desired learning outcomes. This finding, though hardly inconsistent with common sense, provides a firm empirical foundation for an assumption that permeates all systematic instructional development efforts--instruction does indeed make a difference. However, instruction per se is not a unitary variable. Rather, instruction is a constellation of variables such cues, rules, examples, prompts, fading, successive approximations, information redundancy, etc. Clearly, the path is marked for isolating the critical variables that constitute effective instruction. The research strategy outlined in the present experiments of beginning with an effective

TABLE 21

Summary of Experiments I - IV on the Aricraft Instrument Comprehension Task

		Variables Studied							
		Practice		Incentive		Instruction		Feedback	
Experiment	Subjects	Accuracy	Rate	Accuracy	Rate	Accuracy	Rate	Accuracy	Rate
I	AFROTC Cadets	NS	p<.001	NS	p<.001	---	---	---	---
II	ASU Graduate Education Students	---	---	---	---	p<.01	NS	NS	NS
III	ASU Graduate Education Students	NS	NS	---	---	p<.001	NS	---	---
IV	AFROTC Cadets	---	---	---	---	p<.05	p<.05	NS	NS

The results of analyses of variance on both accuracy and rate are presented for each of the variables studied. NS in a cell indicates that the differences observed among groups were not significant; three dashes (---) indicate that the variable was held constant in the study. No provision is made for reporting interaction effects in this table; no significant interactions were obtained in any of the four studies presented here.

instructional product should provide a prototype for such future endeavors.

Although the present research points the way to a detailed functional analysis of instructional variables, it is not clear at present whether the results of these studies can be generalized to tasks of greater complexity than the aircraft instrument comprehension task. Perhaps instruction is not a fundamental determiner of learner performance on tasks which require a shaping of more complex response repertoires, as in the skills we commonly relegate to the psychomotor domain. Clearly, more research is needed in this area to determine the boundary conditions of the effects instruction has in controlling learner behavior.

The following supporting documents are in the R & D Case File at Flying Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, Arizona 85224:

Higgins, N. C. Aircraft Instrument comprehension program: Form B. (AFSC Contract No. F41609-71-C-0027, Task Order No. 3) Tempe. Arizona: Arizona State University, 1973.

Higgins, N. C., and Kearns, D. R. Validation report: Aircraft instrument comprehension: A self-instructional program: Form A. (AFSC Contract No. F41609-71-C-0027, Task Order No. 3) Tempe, Arizona: Arizona State University, 1973.

Higgins, N. C., Kearns, D. R., and Tenpas, B. G. Validation report: Aircraft instrument comprehension: A self-instructional program: Form B. (AFSC Contract No. F41609-71-C-0027, Task Order No. 3) Tempe, Arizona: Arizona State University, 1974.

Kearns, D. R., Tenpas, B. G., and Higgins, N. C. Aircraft instrument comprehension test: Form B. (AFSC Contract No. F41609-71-C-0027, Task Order No. 3) Tempe, Arizona: Arizona State University, 1973.

REFERENCES

Anderson, R. D. Educational psychology. Annual Review of Psychology, 1967, 18, 129-165.

Annett, J. Feedback and human behavior. Baltimore: Penguin Books, 1969.

Briggs, L. J., and Hamilton, N. R. Meaningful learning and retention: Practice and feedback variables. Review of Educational Research, 1964, 34, 545-558.

Gagne, R. M., and Rowher, W. Instructional psychology. Annual Review of Psychology, 1969, 20, 381-418.

Higgins, N. C. Feedback in group instruction. (AFSC Technical Report No. 2021) Tempe, Arizona: Arizona State University Instructional Resources Laboratory, 1972.

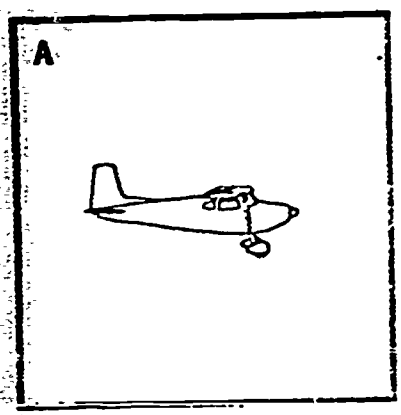
APPENDIX A

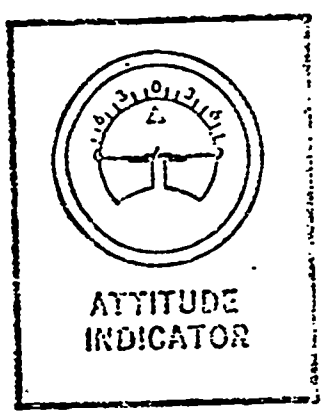
Sample Instructional Materials

Attitude Indicator-Pitch

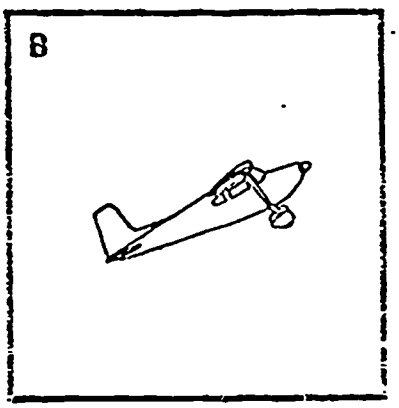
The instrument labeled attitude indicator shows whether the airplane is climbing or diving. This instrument also shows the degree of bank to the right or left.

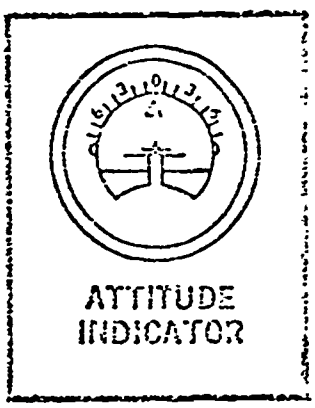
The small aircraft silhouette in this instrument remains stationary. The position of the heavy black line, representing the horizon, varies with the airplane's position.



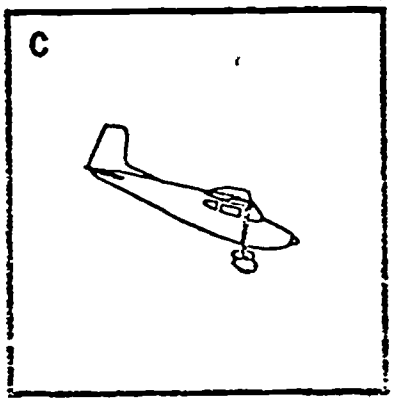


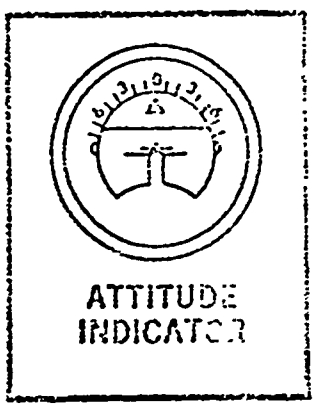
When the airplane is flying level, the horizon line will be directly on the aircraft silhouette as shown above.





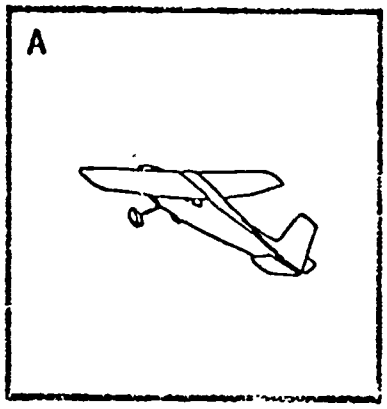
If the airplane is climbing, the silhouette is seen between the horizon line and the triangular pointer.



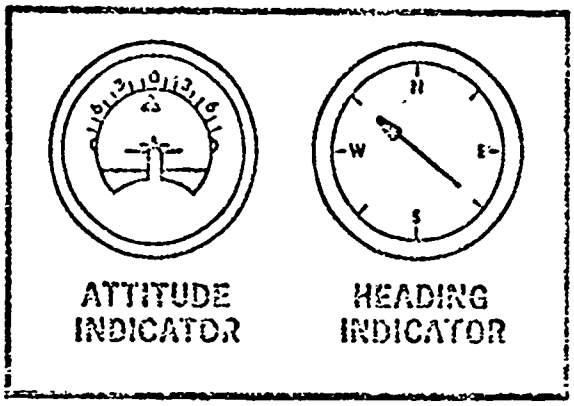


If the airplane is diving, the horizon line will be between the silhouette and the pointer.

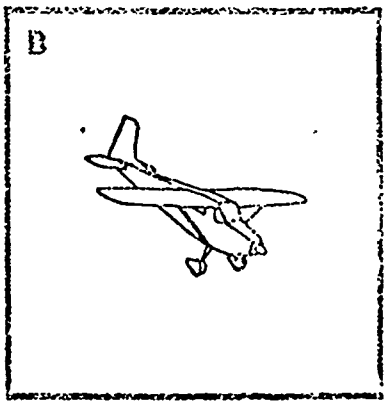
The airplane in Figure A is climbing on a northwest heading.



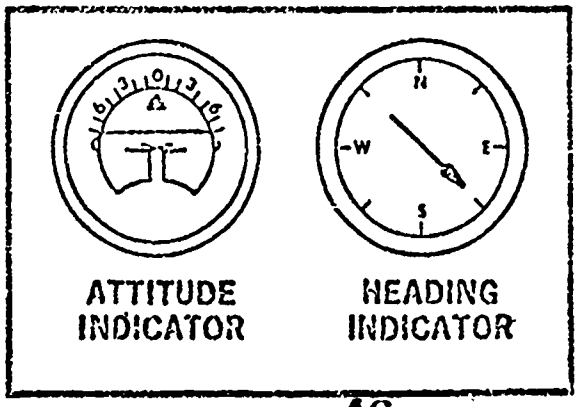
The horizon line is below the aircraft silhouette in the attitude indicator. The arrow in the heading indicator is pointing midway between the N and the W.



The airplane in Figure B is diving on a southeast heading.



The horizon line is above the aircraft silhouette in the attitude indicator. The arrow in the heading indicator is pointing midway between the S and the E.

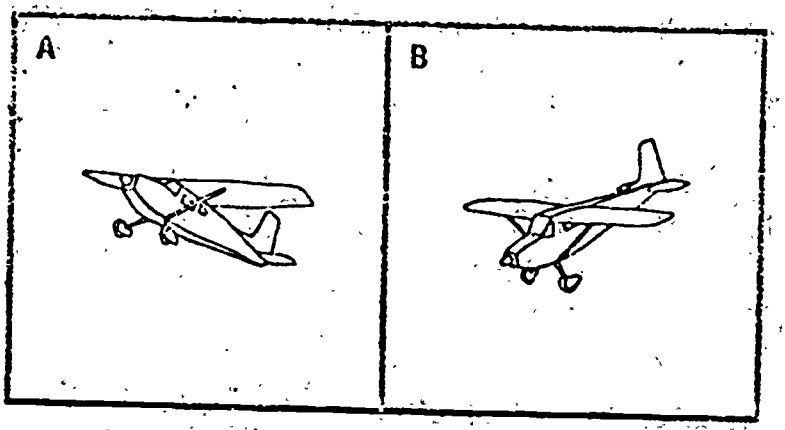


APPENDIX B

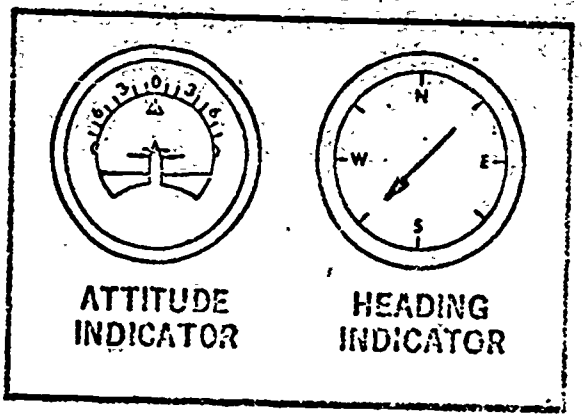
Sample Practice Items

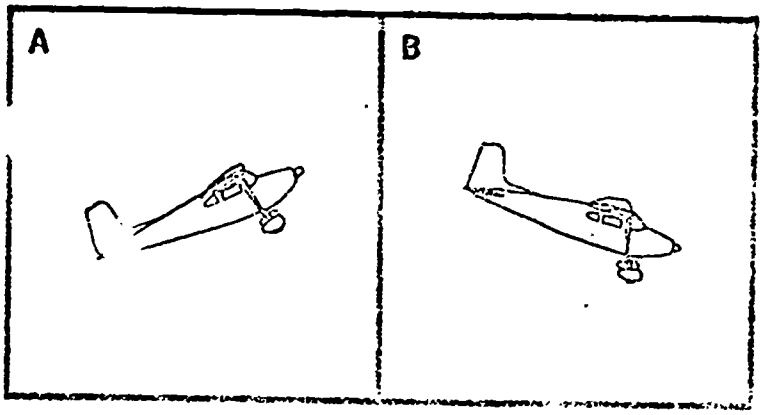
Which of the airplanes pictured below is most nearly in the position indicated on the attitude and heading indicators?

Mark your choices opposite items 2 and 3 on the response sheet.

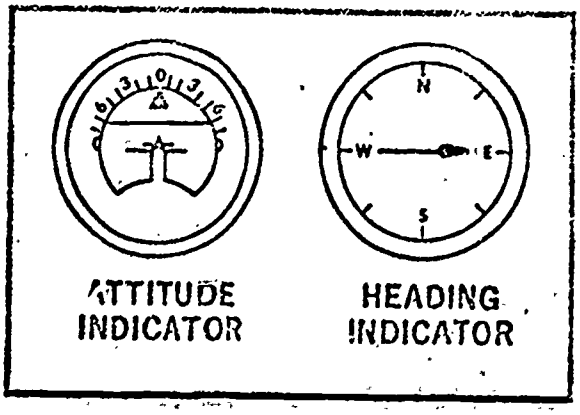


2.



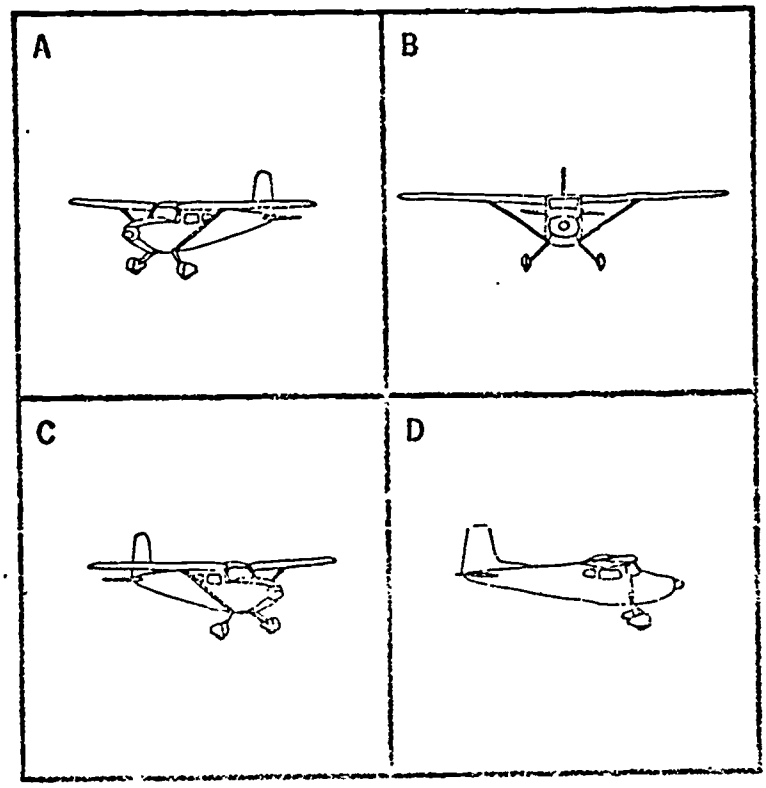


3.

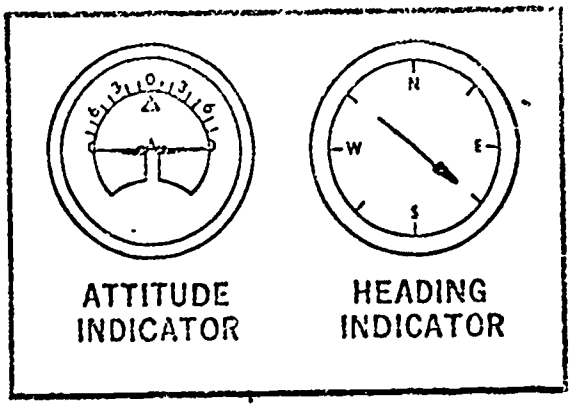


Which of the aircraft pictured below is in the position shown on the instrument panel?

Mark your choice opposite item number 4 on your response sheet.



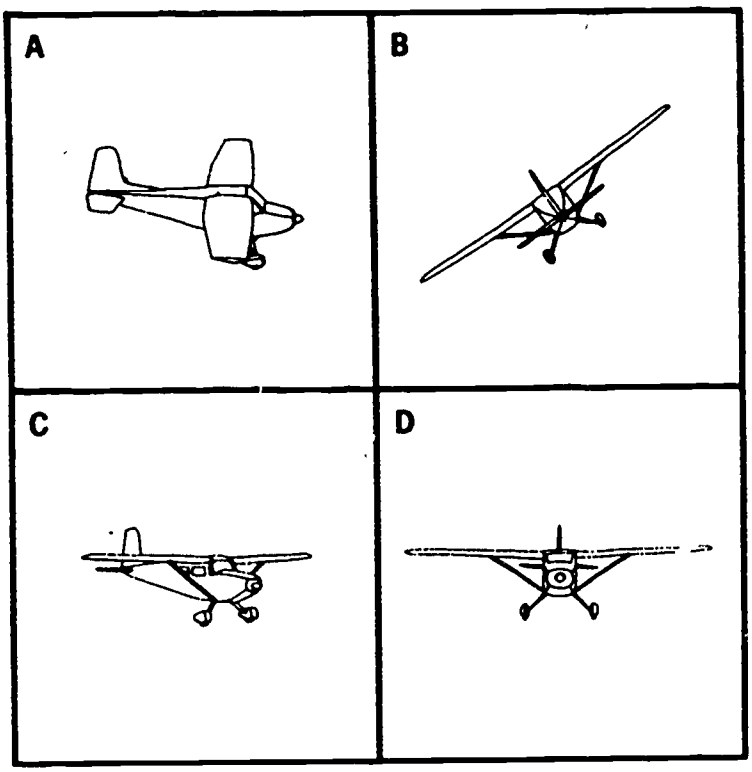
4.



APPENDIX C

Sample Posttest Item

Sample Posttest Item



X.